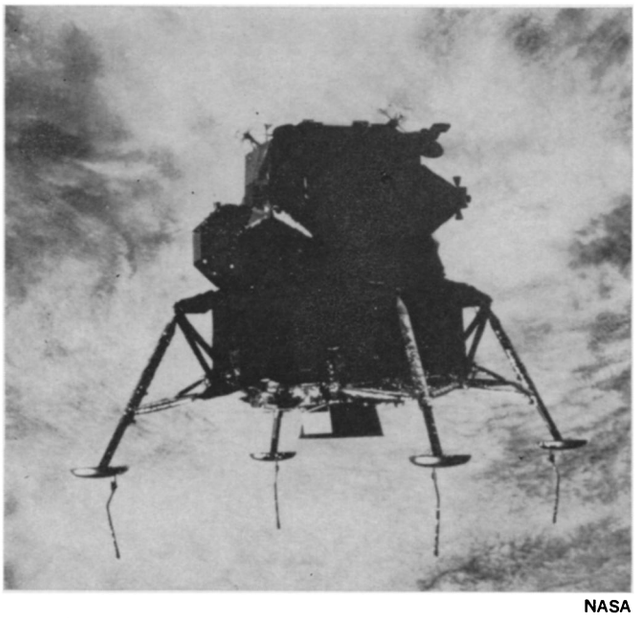
APOLLO

Contaminants on the moon

Scientists fear inevitable earthly pollution that will befoul their first lunar rocks

by Jonathan Eberhart



NASA

LM descent engine nozzle shows amid spacecraft's feet.

To scientists, the first few pounds of rock brought back from the lunar surface will be more valuable than diamonds. Every last grain of moondust transported to earth by the Apollo 11 astronauts in July will be coveted as though it were the key to a whole new world—which it is, or will be if it isn't changed beyond all recognition by the very men and equipment sent to the moon to get it.

Contamination of another planet has been of concern to scientists since the beginning of the space program. It could be the greatest sin ever wrought by man if some earthly organism, against which the planet had no defense, got out of control. But even if it only prevented the recovery of pristine samples for study, it could still be a major crime against science.

Scientists contemplating the July lunar landing of Apollo 11 astronauts are worried about contamination of the moon, but not so much about the planetary sin. Their concern is with the lesser crime: the fear that some particle carried up from the earth might be misinterpreted as a lunar one, with the potential of causing a scientific mistake which could be as grave as the erroneous discovery of life on another world. Some of the analyses to be made of the lunar samples on earth will descend to the sub-molecular level, starting with rock bits sometimes amounting to a gram or less. Thus even minute traces of contamination could cause drastically misleading results.

Pollutants carried by the men or their vehicle are, despite the most rigorous precautions, of constant concern. But by far the largest source of contamination will be the Apollo lunar module's descent engine, which will spew out almost nine tons of propellant exhaust products on its way down to the surface of the moon. As much as 90 percent of this may simply disappear into space, but there could still be 1,700 to 1,800 pounds of exhaust settling on the moon, with the densest concentration around the landing site itself, which is also the area from which the first samples will be collected.

One research team at the Grumman Aircraft Engineering Corp. in Bethpage, Long Island, told the National Aeronautics and Space Administration that contamination from the LM exhaust could total as much as 20 percent of the estimated weight of the lunar atmosphere, "an indication that the moon may soon enjoy its share of terrestrial atmospheric pollution problems." The lunar atmosphere is less than a billionth as dense as earth's, but the contamination could be scientifically significant.

The lunar atmosphere may already be irretrievably contaminated, though probably at levels too low to measure, by unmanned U.S. and Soviet soft-landing spacecraft. Space scientists, however, are more concerned about localized soil contamination.

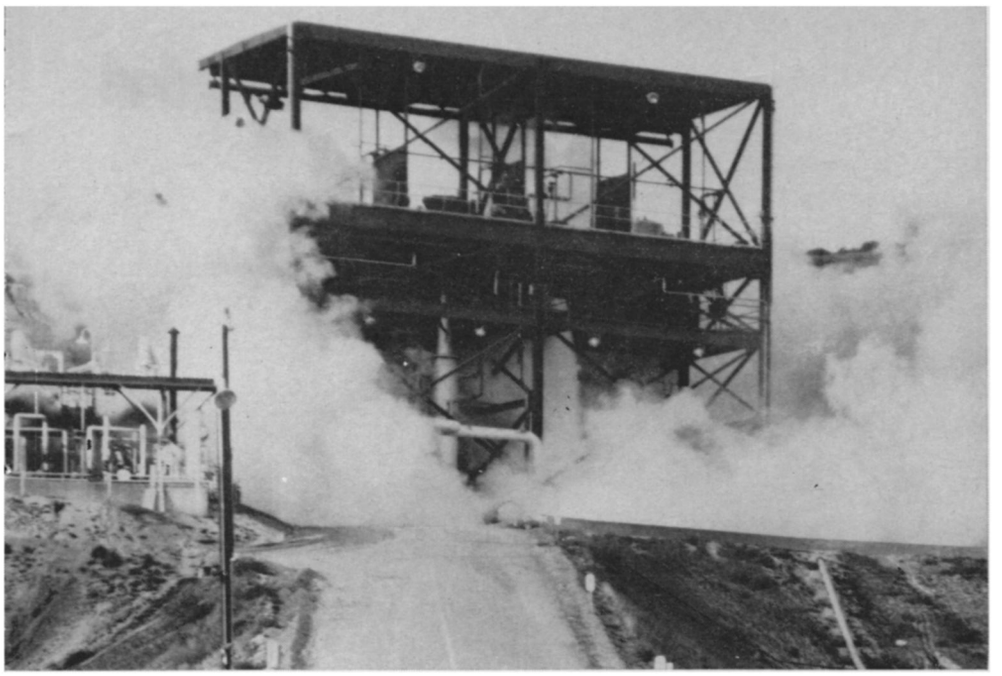
On later landing flights, astronauts will be exploring far enough away from the touchdown point to evade much of their LM ground contamination, and the space agency is studying lunar roving and flying vehicles that would permit samples to be collected from hundreds of miles away. During the first landing, however, the astronauts' surface-walking activities will be kept within 100 feet of the LM. "We see no reason to go any further and use up a lot of energy in walking," says NASA Apollo spacecraft manager George Low.

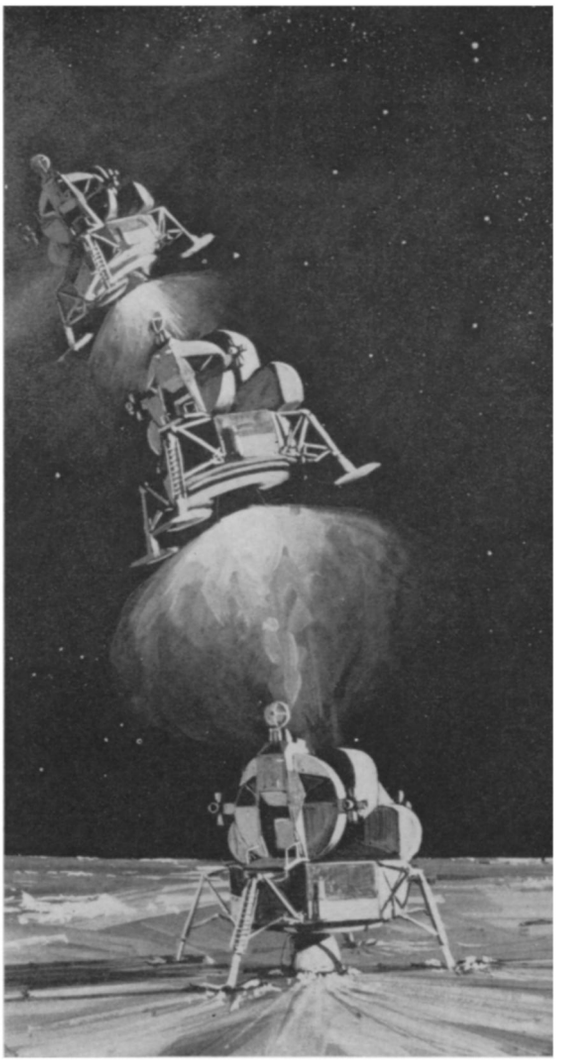
Because the first samples are inevitably going to come from a contaminated area, researchers on earth are working to learn exactly what the contaminants might be, so that scientists can subtract them from their data.

At the White Sands Test Facility near Las Cruces, N.M., exhaust gases from LM descent engine firings are being collected on pumice, salt brine, dry ice and other materials, chosen for the ease with which exhaust products can be separated from them for study. These samples are being analyzed in laboratories as far apart as those of Nobelist Dr. Melvin Calvin at the University of California at Berkeley, and Dr. Oliver Schoeffer at the State University of New York at Stonybrook.

In addition, at Cape Kennedy, samples are being taken of individual batches of LM propellant, which reportedly varies so much due to contaminants in shipping container residues and other factors that NASA sometimes needs to process it to bring it up to specifications. These slight variations might not affect the operation of the LM, but they could confuse scientists trying to analyze lunar samples. Two propellant samples will be taken from the specific propellant batch earmarked for each moonbound LM.

Analysis of the LM exhaust, however, is posing quite a problem. The LM propellants—unsymmetrical dimethylhydrazine and hydrazine with an oxidizer of nitrogen tetroxide—unite on contact in what James Townsend of the lunar and earth sciences division of the NASA Manned Spacecraft Center calls "one of the messiest reactions you can possibly deal with." More than 100





TRW/N. American Rockwell

The pollutants that will spew forth as the LM descends to the moon (right) are obvious in earthbound tests of the vehicle's descent engine (above).

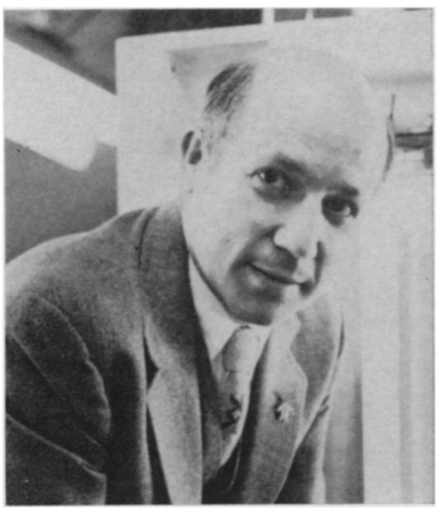
different by-products result from the reaction, including carbon dioxide, nitrous oxide, methane, acetone and others, ranging from tenuous gases that will barely remain on the lunar surface to thick, tarry sludge.

To make matters worse, Townsend says, the products keep reacting and re-reacting together after they have first been formed, so that it is virtually impossible to know what proportions they will be in after the LM has spent a little time on the surface.

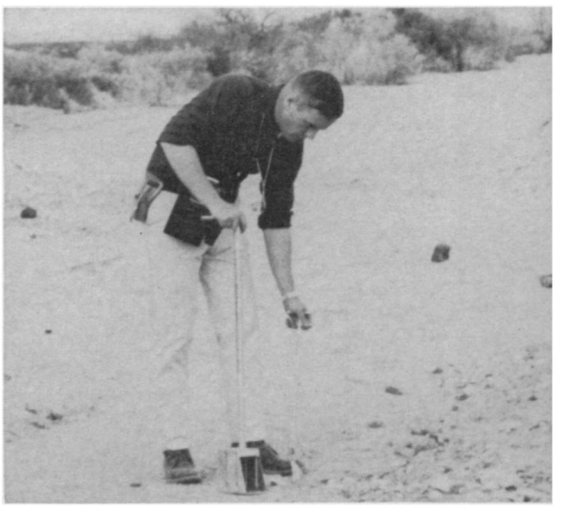
The lunar surface itself could make still more trouble. Billions of years of pounding by high-energy particles from the solar wind may have turned its silica into a catalyst capable of promoting new reactions, possibly with end products unlike those produced in simulations on earth. "In the extreme case of a highly catalytic surface," reported the Grumman research team in 1966, "reaction could be so extensive and rapid that none of the exhaust products would retain its original identity."

A grain of hope here is that water, one of the main LM exhaust products, can sometimes poison silicon catalysts, making them ineffective. The water could also have an adverse effect, however. Although finding water on the moon is extremely unlikely, tiny traces from the exhaust could be misleading. The U.S. Geological Survey estimates that even the dust of a dry dirt road may contain up to 15 percent by weight of water.

The LM propellant by-products, however, will not be the only sources of contamination from the first lunar landing. Besides the burned propellants, the exhaust will also include much of the ablative lining of the engine nozzle, a phenolic resin called Refrasil. Consisting mostly of silicon dioxide, the vaporized Refrasil will also include traces of aluminum, titanium, zirconium, potassium, sodium, calcium, magnesium and boron.



Nobelist Melvin Calvin: Dirt hunt.



NASA

Neil Armstrong tries digging tube.

Townsend's chief concern, in fact, is not the engine exhaust at all, but the unburned propellants in the descent stage. Shortly after the LM settles down on the lunar surface—and before the astronauts have gone out to gather their samples—the propellant tanks will be vented, in order to keep the residual heat from the engine from making the propellants expand to dangerous pressures. This could dump as much as half a ton of propellants onto the moon, Townsend warns, though some researchers, he says, feel that the sudden pressure drop from the opening vent valves will simply make the propellants freeze solid in their tanks.

. . . contaminants

Other sources of contamination include the LM cabin atmosphere, which will be free to be adsorbed onto lunar surface particles when the spacecraft hatch is opened, and the life support systems of the astronauts' space suits. These could add hydrogen sulfide, methane and other compounds, though in small quantities, to the growing mess on the surface.

Space agency researchers have tried to take into account every contamination source they could think of; some were concluded to be so unlikely as to be negligible. Radiation sources used in an early propellant gauge design were studied, but were found to be almost surely too weak to make a detectable difference. Another possibility considered was that during its flight to the moon, part of the LM skin might be made slightly radioactive by contact with high-energy particles, and some of this material could be knocked loose by flying rock during the final descent. This, too, was discounted.

Photochemical reactions due to the solar wind and cosmic rays striking the surface, however, are not being ignored, largely because under unforeseen circumstances they might produce some fairly sophisticated molecules. In studies on earth, carbon monoxide and hydrogen have been photochemically excited with ultraviolet radiation to produce formaldehyde, and even amino acids have been synthesized by electric discharge on mixtures of simple inorganic molecules. These reactions required either high pressures or long periods of time, but others might be possible in the lunar environment.

To get as contamination-free samples as possible, the astronauts are scheduled to do some of their gathering with long digging tubes that can withdraw rocks from beneath the surface. In Houston, at the $11 million Lunar Receiving Laboratory, scientists are preparing to second-guess the contamination that will inevitably get through with some of the most sophisticated instruments in the world.

Most subject to error from contamination will be organic analyses such as mass spectrometry, in which a small, crushed sample is heated until its components vaporize progressively by increasing mass number. Geologists may encounter some misleading color changes due to water in the LM exhaust.

At the LRL, and in other laboratories in the U.S. and abroad, the samples will be probed, pounded, dissolved and otherwise analyzed to make sure that the results—which could hold the keys to the origin of the earth itself—will not be just a cosmic mistake. ◇